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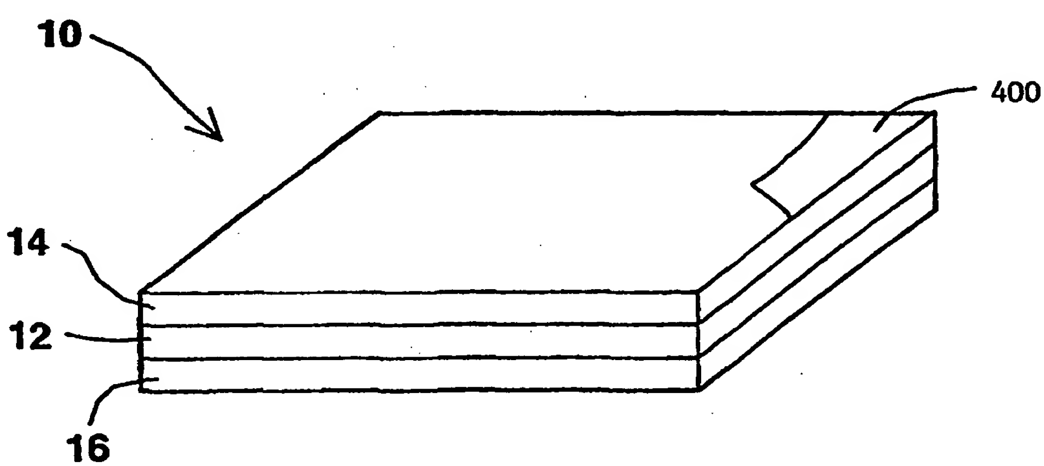

(57) Abstract

This invention is an application comprising an electrically operated device, and a flexible thin layer open liquid state electrochemical cell (10) for providing the device with electrical power for its operation; the electrochemical cell including a first layer of insoluble negative pole (14), a second layer of insoluble positive pole (16), and a third layer of aqueous electrolyte (12); the third layer (12) being disposed between the first (14) and second (16) layers; and including a deliquescent material for keeping the open cell (10) wet at all times, an electroactive soluble material for obtaining required ionic conductivity, a watersoluble polymer for obtaining a required viscosity for adhering the first (14), and second (16) layers to the third (12) layer.

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FLEXIBLE THIN LAYER OPEN ELECTROCHEMICAL CELL AND APPLICATIONS OF SAME

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to electrochemical cells which are used as battery power sources by converting chemical energy to electrical energy. More particularly, the present invention relates to a primary or rechargeable electrochemical cell to be used as a regular or rechargeable battery which accomplishes the conversion of chemical energy to electrical energy using a wet (e.g., liquid state) electrolyte, yet maintain a flexible thin layer and open configuration. The present invention further relates to applications of such cell.

The ever-growing development of miniaturized and portable electrically powered devices of compact design such as for example cellular phones, voice recording and playing devices, watches, motion and still cameras, liquid crystal displays, electronic calculators, IC cards, temperature sensors, hearing aids, pressure sensitive buzzers, etc., generates an ever-growing need of compact thin layer batteries for their operation. Therefore, there is a need for reliable thin layer electrochemical cells to be used as batteries in such devices.

Batteries can be broadly classified into two categories in which the batteries of the first category include wet electrolytes (i.e., liquid state batteries), whereas batteries of the second category include solid state electrolyte. Although solid state batteries have an inherent advantage, they do not dry out and do not leak, they suffer major disadvantages when compared with liquid state batteries since, due to limited diffusion rates of ions through a solid, their operation is temperature dependent to a much larger extent, and many operate well only under elevated temperatures; and, the limited diffusion rates thus described, characterize solid state batteries with low ratio of electrical energy generated vs. their potential chemical energy.

Liquid state thin layer batteries typically include a positive and negative active insoluble material layer put together with a separator interposed therebetween, which separator is soaked with a liquid electrolyte solution, thus functioning as an electrolytic liquid layer. Such batteries, an example of which is disclosed for example in U.S. Pat. No. 4,623,598 to Waki et al., and in Japanese Pat. No. JP 61-55866 to Fuminobu et al., have to be sealed within a sheathing film to prevent liquid evaporation, and are therefore closed electrochemical cells.

Being closed cells, these batteries tend to swell upon storage due to evolution of gases which is a fatal problem in thin layer batteries having no mechanical support, the pressure imposed by the accumulated gases leads to layers separation, thus turning the battery inoperative. Means to overcome this

problem include (i) the use of a polymer increased viscosity agent, such as hydroxyethylcellulose, applied to adhere (i.e., glue) the battery layers together, thus to overcome the inherent problem of such batteries imposed by lack of solid support; and, (ii) addition of mercury to prevent the formation of gases, especially hydrogen. However, the polymer is limited in its effectiveness and the mercury is environmental hazardous.

A way to solve the above described limitation was disclosed in U.S. Pat. No. 3,901,732 to Kis et al. in which a gas-permeable electrolyte-impermeable polymeric material which allows venting of undesirable gases formed within the battery while preventing any electrolyte loss from the battery is used as a sheathing film to enclose the battery cell.

However, a more direct and efficient approach to avoid undesired gas accumulation in liquid state thin layer batteries would be to provide these batteries as open cells for facilitated release of gases, while at the same time to provide means to avoid liquid evaporation and drying out of the battery. Such a construction would permit the production of thin layer batteries devoid of casings, which batteries will therefore be thinner, more flexible and simpler and therefore cheaper for mass production.

There is thus a widely recognized need for, and it would be highly advantageous to have, a flexible thin layer open electrochemical cell devoid of both accumulation of gases and liquid evaporation limitations.

SUMMARY OF THE INVENTION

According to the present invention there is provided a flexible thin layer open liquid state electrochemical cell which can be used as a primary or rechargeable power supply for various miniaturized and portable electrically powered devices of compact design. There is further provided a method of manufacturing such a cell. The flexible thin layer open electrochemical cell of the present invention includes a wet electrolyte, yet maintains a flexible, thin and open configuration, thus devoid of accumulation of gases upon storage.

According to further features in preferred embodiments of the invention described below, the cell comprising a first layer of insoluble negative pole, a second layer of insoluble positive pole and a third layer of aqueous electrolyte, the third layer being disposed between the first and second layers and including: (a) a deliquescent material for keeping the open cell wet at all times; (b) an electroactive soluble material for obtaining required ionic conductivity; and, (c) a watersoluble polymer for obtaining a required viscosity for adhering the first and second layers to the third layer.

This cell is used is employed in various applications according to the present invention, which applications call for a cheap cell having a flexible and thin configuration.

Thus, according to still further features in the described preferred embodiments provided is an application comprising an electrically operated device and a flexible thin layer open liquid state electrochemical cell for providing the device with electrical power for its operation, the electrochemical cell including a first layer of insoluble negative pole, a second layer of insoluble positive pole and a third layer of aqueous electrolyte, the third layer being disposed between the first and second layers and including (a) a deliquescent material for keeping the open cell wet at all times; (b) an electroactive soluble material for obtaining required ionic conductivity; and (c) a watersoluble polymer for obtaining a required viscosity for adhering the first and second layers to the third layer.

According to still further features in the described preferred embodiments the device includes a substrate material and at least one electronic component attached to the substrate material, the at least one electronic component is for performing a sensible performance.

According to still further features in the described preferred embodiments the substrate is selected from the group consisting of a greeting card, a business card, a cinema or theater ticket, a sticker for compact disc (CD), a package of a food product and a printed matter.

According to still further features in the described preferred embodiments the sensible performance is audial or visual, including, but not limited to, a change in color due to the effect of an electrical field/flow of current.

According to still further features in the described preferred embodiments the audial performance is selected from the group consisting of a melody, words of a language and telephone dial tones.

According to still further features in the described preferred embodiments the device includes a power switch.

According to still further features in the described preferred embodiments the at least one electronic component is selected from the group consisting of an audio device and a light emitting device.

According to still further features in the described preferred embodiments the audio device includes an audio chip and an echo chamber.

According to still further features in the described preferred embodiments the light emitting device is a low-current led.

According to still further features in the described preferred embodiments said device is a smart card or tag.

According to still further features in the described preferred embodiments said device is an interactive book.

According to still further features in the described preferred embodiments the device is a timer.

According to still further features in the described preferred embodiments the timer includes a substrate material and a timer chip attached to the substrate material, the timer chip is presetable for timing a time period and for prompting a sensible performance when the time period has elapsed.

According to still further features in the described preferred embodiments the performance is by an audio or light emitting device.

According to still further features in the described preferred embodiments the sensible performance is audial or visual.

According to still further features in the described preferred embodiments the audial performance is selected from the group consisting of a melody, words of a language and an alarm.

According to still further features in the described preferred embodiments the timer chip is programmable.

According to still further features in the described preferred embodiments the timer chip is resetable.

According to still further features in the described preferred embodiments the audio device includes an audio chip and an echo chamber.

According to still further features in the described preferred embodiments the light emitting device is a low-current led.

According to still further features in the described preferred embodiments the timer is a drug timer.

According to still further features in the described preferred embodiments the device is an active pad for transdermal delivery of a compound.

According to still further features in the described preferred embodiments, for the transdermal delivery of the compound, the active pad employs a strategy selected from the group consisting of iontophoresis, ultrasound and electroporation.

According to still further features in the described preferred embodiments the compound is selected from the group consisting of a pharmaceutical compound, a cosmetic compound and an anesthetic compound.

According to still further features in the described preferred embodiments the device is an active pad for transdermal recovery of a compound.

According to still further features in the described preferred embodiments for the transdermal recovery of the compound the active pad employs a strategy selected from the group consisting of iontophoresis, ultrasound and electroporation.

According to still further features in the described preferred embodiments the compound is glucose.

According to still further features in the described preferred embodiments said device is selected from the group consisting of a blood pressure meter, a pulse meter and an ECG meter.

According to still further features in the described preferred embodiments the device is a thermometer.

According to still further features in the described preferred embodiments the thermometer includes a thermistor sensor and an electronic chip, the sensor is for sensing a heat magnitude and converting the heat magnitude into electrical parameter of a magnitude corresponding to the heat, the chip is for quantifying the parameter and for translating the parameter into an output of a temperature value.

According to still further features in the described preferred embodiments the thermometer further includes a display for displaying the temperature value.

According to still further features in the described preferred embodiments the device is a glucose sensor.

According to still further features in the described preferred embodiments said glucose sensor transdermally recovers glucose from a patient, e.g., by reverse iontophoresis.

According to still further features in the described preferred embodiments the glucose sensor includes a needle for rupturing the skin and obtaining a blood sample, a glucose oxidaze based glucose sensor, a potenciostat and an electronic chip for quantifying a glucose level in the blood sample.

According to still further features in the described preferred embodiments the device is a game.

According to still further features in the described preferred embodiments the game includes distributed un-raveled components, the un-raveled components become revealed if current from the cell arrives simultaneously or in a predetermined order to the components, the arrival of current is activated by a player.

According to still further features in the described preferred embodiments provided is a method of making a flexible thin layer open liquid state electrochemical cell comprising the steps of (a) applying a wet ink onto inner

sides of first and second substrates, the ink being current conductor; (b) before drying, applying a positive pole powder on the wet ink of the first substrate and a negative pole powder on the wet ink of the second substrate; (c) wetting a porous substance with an aqueous solution containing a deliquescent material, an electroactive soluble material and a watersoluble polymer; and (d) attaching the first and second substrates to the porous substance, such that the inner sides faces the substance, so that a three layers cell is formed.

According to still further features in the described preferred embodiments the method further comprising the step of (e) prior to step (d) applying glue onto the inner sides of the substrate or to both sides of the substance, the application of glue is in accordance with a geometrical configuration.

According to still further features in the described preferred embodiments the method further comprising the step of (f) following step (d) cutting the three layers cell according to the geometrical configuration.

According to still further features in the described preferred embodiments the cutting is effected by a laser.

According to still further features in the described preferred embodiments the method further comprising the step of (e) adding a decorative application onto at least one of the substrates.

According to still further features in the described preferred embodiments provided is a method of printing a flexible thin layer open liquid state electrochemical cell comprising the steps of (a) printing a first layer of wet ink onto a substrate, the ink being current conductive; (b) before drying, spreading over the first layer a layer of positive pole powder; (c) printing over the layer of positive pole powder a layer of an aqueous solution containing fibers, a deliquescent material, an electroactive soluble material and a watersoluble polymer; (d) before drying, spreading over the layer of aqueous solution a layer of negative pole powder; (e) printing over the layer of negative pole powder a second layer of the ink.

According to still further features in the described preferred embodiments the method further comprising the step of (f) before step (a), printing a conductive layer on the substrate.

According to still further features in the described preferred embodiments the method further comprising the step of (f) following step (e), printing a conductive layer over the second layer of the ink.

Further according to the present invention there is provided a cylindrical battery comprising a rolled flexible thin layer open liquid state electrochemical cell including a first layer of insoluble negative pole, a second layer of insoluble

positive pole and a third layer of aqueous electrolyte, the third layer being disposed between the first and second layers and including (a) a deliquescent material for keeping the open cell wet at all times; (b) an electroactive soluble material for obtaining required ionic conductivity; and (c) a watersoluble polymer for obtaining a required viscosity for adhering the first and second layers to the third layer.

Further according to the present invention there is provided a battery book comprising a plurality of flexible thin layer open liquid state electrochemical cells being detachably assembled into a book assembly, each of the flexible thin layer open liquid state electrochemical cells including a first layer of insoluble negative pole, a second layer of insoluble positive pole and a third layer of aqueous electrolyte, the third layer being disposed between the first and second layers and including (a) a deliquescent material for keeping the open cell wet at all times; (b) an electroactive soluble material for obtaining required ionic conductivity; and (c) a watersoluble polymer for obtaining a required viscosity for adhering the first and second layers to the third layer.

Further according to the present invention there is provided a flexible thin layer open liquid state electrochemical cell comprising a first layer of insoluble negative pole, a second layer of insoluble positive pole and a third layer of aqueous electrolyte, the third layer being disposed between the first and second layers and including (a) a deliquescent material for keeping the open cell wet at all times; (b) an electroactive soluble material for obtaining required ionic conductivity; and (c) a watersoluble polymer for obtaining a required viscosity for adhering the first and second layers to the third layer; the cell further comprising a pH sensor in contact with one of the layers.

Further according to the present invention there is provided a battery fold comprising a plurality of flexible thin layer open liquid state electrochemical cells being assembled head-to tail into a foldable assembly, each of the flexible thin layer open liquid state electrochemical cells including a first layer of insoluble negative pole, a second layer of insoluble positive pole and a third layer of aqueous electrolyte, the third layer being disposed between the first and second layers and including (a) a deliquescent material for keeping the open cell wet at all times; (b) an electroactive soluble material for obtaining required ionic conductivity; and (c) a watersoluble polymer for obtaining a required viscosity for adhering the first and second layers to the third layer.

Further according to the present invention there is provided a compact disc container comprising a container and a sticker attached thereto, the sticker being operable to produce a sensual indication of an audial content of a compact disc expected to be in the container.

According to still further features in the described preferred embodiments the sensual indication is audial and includes an audial display identifiable as said audial content.

The present invention successfully addresses the shortcomings of the presently known configurations by providing a flexible thin layer open electrochemical cell which does not accumulate gases upon storage, yet it is maintained wet and intact by the use of a deliquescent material for keeping it wet at all times and a watersoluble polymer for obtaining the required viscosity for adhering the pole layers to the aqueous electrolyte layer. Further qualities of the cell include having no outer rigid casting therefore it is thin, light and flexible and may be manufactured in any size, shape, color and applied patterns, hence it is suitable for a variety of applications; cost effectiveness; made of environmental and human friendly materials; and, self sticking via an adhesive backing.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. 1 is a perspective view of a basic configuration of a flexible thin layer open electrochemical cell according to the teachings of the present invention;

FIG. 2 is a is a perspective view of another possible configuration of a flexible thin layer open electrochemical cell;

FIGs. 3a and 3b are perspective views of two possible configurations of power supplies formed by a a bi-polar connection of two cells of Figure 1 and Figure 2, respectively, to additively increase the electrical energy obtained of thus formed electrical power supplies;

FIG. 4 is a graph presenting the voltage of a flexible thin layer open electrochemical cell according to the present invention, as measured by a voltmeter, as function of time, under room conditions.

FIG. 5 is schematic depiction of a device which includes a substrate material and at least one electronic component for performing a sensible performance, according to the present invention;

FIG. 6 is schematic cross section of a switch and an echo chamber implemented in the device of Figure 5.

FIG. 7 is schematic depiction of a timer according to the present invention;

FIG. 8 is schematic depiction of an active pas for transdermal delivery of a compound according to the present invention;

FIG. 9 is schematic depiction of a thermometer according to the present invention;

FIG. 10 is schematic depiction of a glucose sensor according to the present invention;

FIG. 11 is schematic depiction of a game according to the present invention;

FIG. 12 is a perspective view of a cylindrical battery formed by rolling a flexible thin layer open electrochemical cell according to the invention into a cylinder;

FIG. 13 is a perspective view of a battery book formed by detachably assembling a plurality of flexible thin layer open electrochemical cells according to the invention into a book assembly;

FIG. 14 is a schematic depiction of an audial ticket operated by a flexible thin layer open electrochemical cell according to the present invention;

FIG. 15 is a schematic depiction of an audial compact disc (CD) sticker operated by a flexible thin layer open electrochemical cell according to the present invention;

FIG. 16 is a perspective view of a pulse/blood pressure meter powered by a flexible thin layer open electrochemical cell according to the present invention;

FIG. 17 is a schematic depiction of a smart card/tag according to the present invention; and

FIG. 18 is a schematic presentation of a plurality of open cells aligned in a head-to-tail configuration, wherein positive and negative pole extensions of neighboring cells are in electrical contact with one another, according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is of a flexible thin layer open electrochemical cell which can be used as a primary or rechargeable power supply for various miniaturized and portable electrical devices of compact design. The flexible thin layer open electrochemical cell of the present invention includes a wet electrolyte, yet maintains a flexible, thin and open configuration, thus devoid of accumulation of gases upon storage. The present invention is further of various devices operable using the flexible thin layer open electrochemical cell.

The principles and operation of a flexible thin layer open electrochemical cell and its applications according to the present invention may be better understood with reference to the drawings and accompanying descriptions.

Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments or of being practiced or carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

Referring now to the drawings, Figure 1 illustrates a basic configuration of the flexible thin layer open electrochemical cell of the present invention, referred to hereinbelow as cell **10**.

Cell **10** includes three layers as follows. A first layer of insoluble negative pole **14**, a second layer of insoluble positive pole **16** and a third layer of aqueous electrolyte **12**. As used in this document, a discharged negative pole is where an oxidation occurs, whereas the positive pole is where reduction occurs. The aqueous electrolyte layer **12** includes a deliquescent (i.e., hygroscopic) material for keeping open cell **10** wet at all times; an electroactive soluble material for obtaining the required ionic conductivity; and a watersoluble polymer for obtaining the required viscosity for adhering pole layers **14** and **16** to aqueous electrolyte layer **12**. Following is a more detailed description of each of layers **14**, **16** and **12** and their role in the operation of open cell **10**.

Aqueous electrolyte layer **12** typically includes a porous insoluble substance, such as, but not limited to, filter paper, plastic membrane, cellulose membrane, cloth, non-woven material (e.g., cotton fibers), etc., the porous substance is soaked with an aqueous solution including three components: a deliquescent material; an electroactive soluble material; and a watersoluble polymer.

The deliquescent material by being hygroscopic maintains cell **10** moisturized at all times. The level of moisture within open cell **10** may vary depending on deliquescent material selection, its concentration and ambient humidity. Suitable deliquescent materials include, but are not limited to, calcium-chloride, calcium-bromide, potassium-biphosphate, hyaluronic acid, potassium-acetate and combinations thereof.

The electroactive soluble material is selected in accordance with the materials of which the negative and positive pole layers are made. A list of frequently used electroactive soluble materials suitable for the present invention includes, for example, zinc-chloride, zinc-bromide and zinc-fluoride for various primary cells and potassium-hydroxide and sulfuric-acid for rechargeable cells.

The watersoluble polymer is employed as an adhesive agent to adhere

(i.e., glue) pole layers **14** and **16** to the aqueous electrolyte layer **12**. Many types of polymers are suitable ones, such as, for example, polyvinylalcohol, poliacrylamide, polyacrylic acid, polyvinylpyrolidone, polyethylenoxide, agar, agarose, starch, hydroxyethylcellulose and combinations and copolymers thereof.

Each of negative and positive pole layers **14** and **16** includes a mix of a suitable (negative or positive, respectively) active insoluble powder material along with an aqueous solution similar to the solution described hereinabove, which includes a deliquescent material; an electroactive soluble material; and a watersoluble polymer.

It is clear to one having ordinary skills in the art that while the electroactive soluble material should not change, the deliquescent material and the watersoluble polymer may be selected otherwise in the later solution, in other words, the electroactive soluble material should be kept the same in all three layers **12, 14** and **16,** whereas the deliquescent material and the watersoluble polymer may vary among the layers, according to the specific application.

Appropriate selection of active insoluble powder materials for the negative **14** and positive **16** pole layers with a matching electroactive soluble material, as exemplified hereinbelow in the Examples section, provides a flexible thin layer cell which can be used as a power supply (i.e., a battery), which cell is open and therefore does not accumulate gases upon storage, yet the hygroscopicality of the deliquescent material ensures that the cell is kept wet at all times although open.

Suitable pairs of materials to be used in negative **14** and positive **16** poles include, but are not limited to, manganese-dioxide/zinc; silver-oxide/zinc; cadmium/nickel-oxide; and iron/nickel-oxide (the manganese-dioxide and the silver-oxide are optionally mixed with a conductive carbon powder, as known in the art). Zinc may be applied as a layer of zinc powder pressed to form a layer. Adhesive or conductive ink may be employed to strengthen the zinc layer. Such a layer may also function as a collector, similar to carbon or conductive inks, as further detailed below.

It is clear to one having ordinary skills in the art that a single material may function both as a deliquescent material and as the electroactive soluble material. Such a material should however acquire suitable electroactive and hygroscopic characteristics. Suitable materials of this type include, but are not limited to, zinc-chloride and zinc-bromide.

It is further clear to one having ordinary skills in the art that a single material may function as a deliquescent material and as a watersoluble polymer. Such a material should however acquire suitable hygroscopic and adhesiveness

characteristics. Suitable materials of this type include, but are not limited to, dextrane, dextranesulfate and combinations and copolymers thereof.

The three layers **12**, **14** and **16**, presented in Figure 1 and described hereinabove may be manufactured thin and are flexible, therefore cell **10** is flexible and as thin as 0.3 or less to 1.5 mm. It is presently preferred and will be further detailed below that cell **10** will be manufactured by a suitable printing technology. Suitable printing technologies include, but are not limited to, silk print, offset print, jet printing, lamination, materials evaporation and powder dispersion.

Another possible configuration is shown in Figure 2 illustrating a cell, generally assigned **20**. As cell **10**, cell **20** also includes layers **12**, **14** and **16** (stripped region) forming a basic cell. Cell **20** further includes additional one or two conductive layers **22** and **24**, to improve the electronic conductivity of negative **14** and/or positive **16** pole layers. Suitable conductive layers are graphite paper, carbon cloth, and conductive inks, such as but not limited to, metal inks, including gold, silver and copper inks, etc. Cell **20** also includes negative **26** and positive **28** terminals, which terminals **26** and **28** are in electrical contact with either the corresponding pole layer **14** and **16**, respectively, or with the corresponding conductive layer **22** and **24**, respectively, or both. Terminals **26** and **28** are made of any suitable materials such as, but not limited to, graphite or metals such as iron, nickel, titanium, copper, stainless steel and mixtures thereof, and are preferably applied to cell **20** by a suitable printing technology such as those listed above.

Terminals **26** and **28** are used to electrically connect cell **20** to a load such as an electrical device. Terminals **26** and **28** may be located in any desired location of cell **20**, may acquire any suitable shape and size and, depending on the specific application, terminals **26** and **28** may protrude from the surface and dimensions of cell **20**. Cell **20** may further include at least one externally located adhesive backing **29**, to enable attaching cell **20** to various surfaces, and/or at least one externally located lamina protective layer **30** to physically protect all other layers.

Yet another configuration is shown in Figures 3a-b. Two or more cells **10**, as shown in Figure 3a, or cells **20**, as shown in Figure 3b, may be electrically connected by a bi-polar connection to additively increase the electrical energy obtained of thus formed electrical power supplies **40** and **50**, respectively. For this purpose two or more cells are adhered to one another in a head to tail orientation, as indicated in Figures 3a-b by layers **22**, **14**, **12**, **16** and **24** arrangement, by a conductive double sided adhesive tape, or a conductive glue

layer **42** applied for example by a suitable printing technology, and enabling passage of electrons between adjacent cells.

It is clear that electrical power supplies **40** and/or **50** may further include externally located adhesive backing(s) similar to surface **29** shown in Figure 2 and/or externally located lamina protective layer(s), similar to layer **30** shown in Figure 2. It is further clear that electrical power supplies **40** and **50** may include a negative and a positive terminal similar to terminals **26** and **28**, respectively, of Figure 2.

Referring now to Figure 12, according to an embodiment of the present invention, a cell **300** according to any of the configurations described herein is rolled into a cylinder shaped battery **301**. An adhesive is preferably used to keep the cylinder together.

Referring now to Figure 13, according to another embodiment of the present invention, a plurality of cells **300** according to any of the configurations described herein are detachably assembled into a book assembly **302**, from which single cells or batteries **300** may be removed for use. Cells **300** may be dimensioned as required. One example for using battery **300** is as an emergency disposable battery for cellular phones and other electrically operated devices, especially portable devices, including note-book computers.

Referring now to Figure 18, according to another embodiment of the present invention, a plurality of cells **300** according to any of the configurations described herein are aligned in a head-to-tail configuration, wherein positive and negative pole extensions **339** of neighboring cells are in electrical contact with one another, functioning as terminals for serial connection, resulting in voltage multiplicity. Such a battery fold construction may be easily accomplished using printing technology. The resultant battery fold construction is foldable accordion-like, so as to occupy minimal space. Extensions **339** preferably include a collector, such as, but not limited to, carbon powder, separating between neighboring cells **300**.

Referring again to Figure 1, according to a preferred embodiment of the present invention cell **10** further includes a pH sensor **400** attached thereto. Sensor **400** senses the pH of cell **10** and undergoes a change (e.g., a color change) informative of the pH value of cell **10**. Thus, sensor **400** provides a user with information relating to the operating capabilities of cell **10**. pH sensors are well known in the art and require no further description herein. Such sensors may be applied to cell **10** using printing technology.

The present invention further provides a method of making a flexible thin layer open liquid state electrochemical cells similar to the cells described above,

the method includes the steps of (a) wetting a porous substance with an aqueous solution containing a deliquescent material, an electroactive soluble material and a watersoluble polymer; wetting may be achieved by either dipping or printing technologies; (b) applying onto one side of the porous substance a negative pole layer; and, (c) applying onto the second side of the porous substance a positive pole layer. The negative and positive pole layers include active insoluble powder substances mixed with the deliquescent material, electroactive soluble material and watersoluble polymer preferably of the same types as under (a), and are preferably applied using a suitable printing technology selected for example from those listed above.

The method may further include adding to the cell additional layers and parts, such as but not limited to, externally located adhesive backing(s) and/or lamina protective layer(s), and negative and a positive terminals.

Yet, the method may further include bi-polar joining of two or more cells, for example with a conductive double sided adhesive tape or a conductive glue layer applied for example by a suitable printing technology, to form a power supply with an increased power (e.g., substantially doubled, tripled, etc.). According to the present invention such bi-polar joining may be performed by joining together in a head to tail orientation two or more premanufactured cells, or alternatively, directly manufacturing two or more cells thus oriented, by applying suitable layer one after the other, preferably using a suitable printing technology as described above.

The flexible thin layer open electrochemical cell of the present invention has a major advantage over prior art thin layer cells. Since it is an open cell it does not accumulate gases upon storage, yet it is maintained wet and intact by the use of a deliquescent material for keeping it wet at all times and a watersoluble polymer for obtaining the required viscosity for adhering the pole layers to the aqueous electrolyte layer.

The flexible thin layer open electrochemical cell of the present invention has other qualities as follows. First, it has no outer rigid casting therefore it is thin light and flexible and may be manufactured in any size, shape, color and applied patterns, hence it is suitable for a variety of applications. Second, by using a suitable printing technology for its manufacturing its cost is reduced and therefore it may be disposed after use partly since large sheets can be produced and cut to any desired size following printing and partly since this technology is inherently cost effective. Third, it is preferably made of environmental and human friendly materials (it preferably contains no mercury or heavy metals). And finally, it may be manufactured self sticking via an adhesive backing.

Reference in now made to the following examples, which together with the above descriptions, illustrate the invention.

EXAMPLE 1

A solution containing 120 mg of polyvinylalcohol (an aqueous soluble polymer) and 1680 mg of zinc-chloride (a deliquescent material and an electroactive soluble material) in 1.2 ml of water was prepared. This solution had a glue like viscous appearance. A 4.5 cm x 7 cm strip of a filter paper was thoroughly wetted with this solution by a printing or dipping technologies. A mixture of 300 mg zinc powder with the above solution was prepared and was printed on one side of the paper strip serving as the negative pole layer. On the other side printed was a mixture of 250 mg manganese-dioxide and 50 mg of a conductive carbon powder, together with the above solution, serving as the positive pole layer. When electrical contacts were made with both sides and were connected over a load an electrical current was measured. A current of 12 microampers per cm^2 at a voltage of 1.7÷1.2 volts was easily maintained for five days continuously under room conditions.

EXAMPLE 2

An open cell was prepared as described under Example 1 above and was connected to a voltmeter. As shown in Figure 4, measurement of the voltage produced by the cell under room conditions revealed a pronounced voltage of 1.7 ÷1.2 sustained for nine successive days.

EXAMPLE 3

A saturated potassium-hydroxide solution is prepared and brought to the viscosity of a glue by mixing with a water soluble polymer. A porous substance (e.g., a filter paper) is thoroughly wetted with this solution and a mixture of the solution with nickel-oxide powder is pasted on one side of the porous substance to form a positive pole layer and, a similar mixture with cadmium powder is pasted on the other side of the porous substance to form a negative pole layer. By connecting a voltmeter to the two sides a voltage of 1.2 volts is measured and a high current is measured when the two layers are contacted over a load. The cell does not dry out in the open and can be recharged if so desired.

EXAMPLE 4

The same potassium-hydroxide solution as in Example 3 is prepared and a porous substance is wetted with it. A mixture of the solution with zinc powder is pasted on one side of the porous substance to form a negative pole layer and a similar mixture with silver-oxide powder containing some carbon powder if so desired is pasted on the other side of the porous substance to form a positive pole layer. By connecting a voltmeter to the two sides a voltage of 1.2 volts is measured and appreciable current is measured when the two layers are contacted over a load. The cell does not dry out in the open and can be recharged if so desired.

EXAMPLE 5

The same potassium-hydroxide solution as in Example 3 is prepared and a porous substance is wetted with it. A mixture of the solution with zinc powder is pasted on one side of the porous substance to form a negative pole layer and a similar mixture with manganese-dioxide powder containing some carbon powder if so desired is pasted on the other side of the porous substance to form a positive pole layer. By connecting a voltmeter to the two sides a voltage of 1.5 volts is measured and appreciable current is measured when the two layers are contacted over a load. The cell does not dry out in the open. Recharging thus formed cell may be troublesome.

EXAMPLE 6

The same potassium-hydroxide solution as in Example 3 is prepared and a porous substance is wetted with it. A mixture of the solution with nickel-oxide powder is pasted on one side of the porous substance to form a positive pole layer and a similar mixture with iron powder is pasted on the other side of the porous substance to form a negative pole layer. By connecting a voltmeter to the two sides a voltage of 0.9 volts is measured and a current can be measured when the two layers are contacted over a load. The cell does not dry out in the open and some recharged is possible if so desired.

EXAMPLE 7

A 30% sulfuric acid solution is prepared and brought to the viscosity of a glue by mixing with a water soluble polymer. A porous substance (e.g., a filter paper) is thoroughly wetted with this solution and a mixture of the solution with lead-oxide is pasted on both sides of the porous substance. Both sides are connected to a power supply and a voltage higher than 2 volts is applied by which

the cell is charged. Charge and discharge cycles can be repeated without the cell drying out in the open.

The following Example concerns applications using the open cell as described above as a power source.

EXAMPLE 8

The cell hereinabove described and exemplified may be used in various applications taking advantage of its thinness, lightness flexibility a low manufacturing costs. These qualities render the cell a highly suitable power source for the operation of disposable devices and devices which should maintain a certain flexibility in order to operate well.

In general, any application according to the present invention includes an electrically operated device and a flexible thin layer open liquid state electrochemical cell as hereinabove described. The cell serves for providing the device with electrical power for its operation. Depending on the specific application, the devices described hereinbelow to obtain power from the open cell of the present invention may be manufactured using printing technology, wherein both the open cell layers and the electronic components are applied by that technology. In particular, if the cell configuration includes conductive layers, such as metal ink layers, also known in the art of batteries as collectors, these metal layers, themselves being printed, may serve as terminals for contacting other printed electronic components.

Once a device according to the present invention is printed, is includes a certain topography, which may be protected by a suitable casing. The casing may be formed of a moldable material, such as, but not limited to, foamed polyethylene or polyvynylalcohol, etc. The mold may be the device itself or a replica thereof. Other procedures to form a casing featuring topography which matches that of a specific device is by cutting, hot press of the casing with a replica of the device, or any other method effective in forming a matching topography to an existing predefined one. In any case, the cell may be further encased in layers of external substrates, such as, but not limited to, milar, Lexan polyethylene foil or paper, onto which printed application may be added. These layers may be applied using cold or hot press, depending on the specific application.

With reference now to Figure 5, in one application the device includes a substrate material such as paper, carton or plastic board **200** and at least one electronic component **202**. Electronic component(s) **202** is attached to substrate

material **200** either by adhering or by directly printing electronic component(s) **202** or parts thereof onto substrate **202**.

Electronic component **202** is for performing a sensible performance, which is defined herein as a performance which may be sensed by one of the senses of a human being.

Substrate material **200** may take any suitable shape and be used as, for example, a greeting card, a business card, a package of a food product or any type of printed matter, such as, but not limited to, a magazine, a notebook, a diary, etc. One interesting application of the present invention is in interactive books for children. Such books are well known in the art to include battery operated visual and audial displays. Due to its thinness and flexibility the cell according to the present invention is suitable for use in interactive books. According to a preferred embodiment the book and the battery are provided in a separated form, wherein when the book is used a battery is adhered thereon to serve as a power source for its operation. When exhausted the battery is replaced by a fresh one. Additional application are described hereinunder with respect to Figures 14 and 15.

The sensible performance may thus be used to deliver a message or any type of information to the user or may serve a pleasure in the form of, for example, a melody or a lighting pattern. A pixels and/or graphic electronic display **231** may also be included, as well known in the art.

Thus, in a preferred embodiment of the invention the sensible performance is audial and/or visual. The audial performance may be of any type and may therefore include a melody, words of a language and/or telephone dial tones. The visual performance may, for example, be of light, of a moving object or of change in color due to the effect of an electrical field/flow of current as for example described in U.S. Pat No. 4,779,962, which is incorporated by reference as if fully set forth herein.

Displayed telephone dial tones may be used in combination with a dual tone multi frequency (DTMF) device attached to a telephone set to dial the toned telephone number, as well known in the art of telephonia.

Electronic component **202** is preferably printed onto substrate material **200**, as well as open cell **206**, its terminals **208** and the required circuit connections **210**. Methods of printing electronic components are well known in the art. One example is U.S. Pat. Nos. 4,353,954 and 4,562,119, both are incorporated by reference as if fully set forth herein. Methods of printing the open cell according to the present invention onto a substrate are described hereinbelow.

In a preferred embodiment of the invention the device includes a power switch **204**. Switch **204** is used to operate the device and to stop its operation, if so required.

As shown in Figure 6, in a preferred embodiment of the invention, switch **204** is formed within two layers **212** of material **200**, wherein one of the layers is formed with an elevation **214** covered from the inside with a conductive material, e.g., a layer of conductive carbon or ink (say metal ink), which is positioned above terminals **218**, such that pressing elevation **214** results in closing an electrical circuit. In fact, due to the flexibility of the open cell according to the present invention, any hole formed through its layers, which hole is covered by a conductor on one side thereof and engaging terminals on the other side thereof may serve as an on/off switch according to the invention by simply pressing the conductor to become in contact with the terminals. Thus, the flexibility of the cell serves to effect a function of reversible separation of switch ends.

As further shown in Figure 5, in a preferred embodiment of the invention electronic component **202** is an audio device **220** which includes an audio (voice) chip **221** (e.g., the voice chip "CHIP ON BOARD" distributed by CoMedia Ltd. Hong Kong, Cat. # A53915) and preferably an echo chamber **224** (e.g., the echo chamber "piezoelectric sounder/speaker" distributed by muRata, Holbeinstrasse 21-23 D 8500 Nurenberg 70, Germany) and/or a light emitting device **222**. In a preferred embodiment light emitting device **222** is a low-current led **223**. Voice chip **221** may record sounds and display the recorded sounds upon command.

As further shown in Figure 6, in a preferred embodiment of the invention, chamber **224** is formed, similar to switch **204**, within layers **212**, wherein one of the layers is formed with an elevation **226** and, preferably, with an opening **228**. Within the void **229** thus formed positioned is a vibrating membrane **230**, which is connected to a piezoelectric component **232**, which vibrates according to instructions received from audio chip **221** (shown in Figure 5). The combination of membrane **230** and component **232** is known in the art as a piazoceramic plate.

The above described application according to any of its configurations may be used, for example, in audial greeting cards which play an audial greeting when operated (e.g., when opened), as audial theater/cinema tickets, which play a well recognized part of the e.g., melody, text, etc., of their respective show/movie, and as audial stickers for CDs, which play a part of the audial content of the CD. Such a ticket **304** is shown in Figure 14, whereas such a sticker **306** is shown attached to a CD container **308** in Figure 15. In fact, any small/thin battery is suitable for the operation of the audial stickers.

With reference to Figure 7, according to another embodiment of the invention the device is a timer **240**. Preferably, timer **240** includes a substrate **242** onto which an open cell **206** according to the present invention is attached, either adhered or printed. Timer **240** further includes a timer chip **244** which can be reset for timing a time period and for prompting a sensible performance when the time period has elapsed. A suitable timer chip is distributed by National Semiconductor Corp., CA, Cat. # COP888.

As before, the sensible performance is preferably enacted by an audio and/or light emitting device **246**, such that the sensible performance is audial (e.g., a melody, words of a language or an alarm) and/or visual.

In a preferred embodiment of the invention timer chip **244** is programmable, i.e., the time period elapses between resetting and prompting the sensible performance is programmable.

Programming is preferably performed by an external programming device **249** (e.g., a computer) which can be connected via suitable connections **248** formed in timer **240** to chip **244**. One having ordinary skills in the art would know how to select the required connections between programming device and device **240**, so as to enable programming as hereinabove described.

In one embodiment the timer serves in electronic parking toll applications.

In another embodiment the timer serves as a drug timer, i.e., it indicates that time to take a drug has arrived. In this case substrate **242** is preferably formed as a sticker which may be adhered to a drug container. In this case, the pharmacist would program chip **244** as required for a specific drug via programming device **249** and would adhere timer **240** to the drug container.

In this case, programming device preferably further includes a printer for printing various details such as the drug, the date, the name of the patient and the schedule according to which the drug is to be taken.

Preferably drug timer **240** includes two reset switches **204**, which reset timer **240** only when pressed simultaneously, as to avoid accidental reset.

Another use of the open cell according to the present invention is in the active transdermal delivery of compounds such as pharmaceutical, cosmetic and anesthetic compounds.

Figure 8 presents an active pad or patch **250** for transdermal delivery of a compound. Pad **250** has one side **252** which may adhere to the skin of a user. Pad **250** includes the compound which is to be transdermally delivered.

Active transdermal delivery of compounds into the body is well known in the art. Few strategies are employed for transdermal active drug delivery.

Iontophoresis, is employed to deliver small charged molecules across the skin. In this case the compound molecules follow a path dictated by their self charge and the charge imposed on the pad by a power source.

Electroporation employs short and strong pulses of electricity to create temporary openings in the skin through which large molecules can pass.

Ultrasound employs high-pitched sound to temporarily disrupt the skin's structure, creating microscopic holes through which large molecules can pass.

According to the strategy employed pad **250** is equipped with the required electronics and/or an ultrasound generator **254**.

Further details concerning the functionality and precise construction of active pads are well known in the art and require no further description. Such details are found, for example, in "Breaking the skin barrier", by Ingrid Wickelgren, Popular Science, December 1996, pp. 86-89, "Controlled drug delivery fundamentals and applications". Second edition, J. R. Robinson and V. H. L. Lee editors, Marceldekker Inc. New York, 1987, and U.S. Pat. Nos. 5,169,384; 4,763,660; 5,443,441 and 3,447,537, all are incorporated by reference as if fully set forth herein.

The open cell described above has advantages in use for transdermal drug delivery pads due to its thinness, flexibility and light weigh.

Therefore, according to the present invention pad **250** is supplemented with such a cell **206**, which serve as a power source for generating the iontophoresis, ultrasound or electroporation effects, which are required for active transdermal drug delivery.

Currently distributed products for transdermal drug delivery include the "LECTRP PARCH" and the "E-TRANS - ELECTROTRANSPORT".

Figure 8 will now be used to present an active pad or patch **250'** for transdermal recovery of a compound from the body. Like pad **250**, pad **250'** has one side **252'** which may adhere to the skin of a user. Pad **250'** is directed at adsorbing the compound from the body.

Active transdermal recovery of compounds from the body is well known in the art and may employ reverse iontophoresis, reverse electroporation and reverse ultrasound. For example, reverse iontophoresis is used in transdermal recovery of glucose for monitoring blood glucose levels in, for example, diabetic patients. A reverse iontophoresis blood glucose monitoring device is manufactured by SpectRx in collaboration with Abbott/MediSense. Another device is manufactured by Cygnus Inc., known as GLUCOWATCH. A review discussing the "Factors affecting electroosmotic extraction of glucose" were discussed by J. A. Tamada, K. Comyns and R. O. Potts, of Cygnus Inc., 400

Penobscot Drive, Redwood City, CA 94063, USA, in the "Symposium of transdermal administration, a case study iontophoresis", held in Paris, March 2-4, 1997.

According to the strategy employed pad **250'** is equipped with the required electronics and/or an ultrasound generator **254'**.

Further details concerning the functionality and precise construction of active recovery pads are well known in the art and require no further description. Prior art active recovery pads are manufactured by Cygnus Inc. CA, USA.

The open cell described above has advantages in use for transdermal recovery pads due to its flexibility and light weigh. In addition, all the electronics of such pads may be applied by printing technology onto the pad itself, including the battery for its operation. Thus, the electronics are integrated with the reservoir dedicated to store the drug or delivered substance.

Therefore, according to the present invention pad **250'** is supplemented with such a cell **206**, which serve as a power source for generating the iontophoresis, ultrasound or electroporation effects, which are required for active transdermal recovery.

Another use of the open cell according to the present invention is in temperature determinations. Shown in Figure 9 is an electric thermometer **260** which employs the open cell according to the invention as a power source **206** for a thermistor sensor **262** which serves for sensing a heat magnitude and converting it into an electrical parameter (e.g., resistance, voltage, etc.) of a magnitude corresponding to the heat. A suitable thermistor is distributed by Beta Therm Cat. # 1K7A1. Thermometer **260** further includes an electronic chip **264** for quantifying the electrical parameter and for translating it into an output of a temperature value.

Thermometer **260** further includes a display **266** for displaying the temperature value. Display **260** may include a set of small leds arranged along a temperature scale, such that when a specific led operates, the user can read the temperature from the scale.

Another use of the open cell according to the present invention is in glucose level determinations.

Diabetes is a chronic life-threatening disease which affects over 100 million worldwide. The disease is characterized by the body's inability to properly control its glucose metabolism, most often because of inadequate secretion of the hormone insulin by the pancreas. In normal individuals, when blood glucose begins to rise, a continuous physiological feedback mechanism instructs the pancreas to secrete the appropriate amount of insulin and thereby

bring the glucose level down. Diabetics lack this capability and, if untreated, suffer from an uncontrolled blood sugar level with consequent metabolic and circulatory problems that are often crippling of fatal.

In insulin-dependent diabetes, the body's lack of natural insulin is compensated by injections, usually administered several times daily. Insulin dosage, however, must be carefully controlled and excessive insulin will lead to hypoglycemia, low blood glucose, which can cause seizures, brain damage and death. Therefor, most patients receiving insulin therapy must also monitor their blood glucose level, in order to properly regulate the balance their sugar intake and insulin dosage.

The preferred and most common method of ambulatory blood glucose monitoring today is by blood test. Portable blood testing devices include three elements: a needle, enzymatic biosensing material, and an electric reader (optical or resistance). The patient pricks his/her finger with the needle and draws a drop of blood onto a test strip. A biosensing material impregnated on the strip changes color or produces electrochemical current in proportion to the concentration of glucose in the sample. These kits are widely available, including digital-readout meters.

Shown in Figure 9 is a glucose sensor **270**. Sensor **270** includes a needle **272** for rupturing the skin (e.g., the finger skin) of the user and obtaining a blood sample thereof. Needle **272** is preferably a platinum needle. Sensor **270** further includes a glucose oxidaze based glucose sensor **274**, a potenciostat **276** and an electronic chip **277** for quantifying the glucose level in the blood sample. Sensor **270** further includes a display **278** for presenting the level of glucose measured in the blood sample in conventional units of concentration (e.g., mg/dl).

The operation of each of the components mentioned in glucose level determinations is well know in the art. Prior art glucose sensors are distributed by, for example, LifeScan Inc. and MediSense Inc. USA.

According to the present invention, as a power source for the operation of glucose sensor **270** serves the inventive open cell **206**.

Another use of the open cell according to the present invention is in pulsemeters, blood pressure and/or ECG meters. Various methods are presently employed to monitor pulse and blood pressure. These include monitoring pressure, acoustical and optical oscillations associated with the body pulsation. Such devices, in disposable and reusable forms are manufactures by few manufacturers, including Nonin Medical Inc. of 2605 Fernbrook Lane North, Plymouth, MN 55447-4755, USA; and Sein Electronics Co., Ltd. of #133-3, Pyungchon-dong, Dongan-gu, Anyang-city, Kyungki-do, Korea. The meters

manufactured by these companies include conventional AAA or button batteries. A great advantage, especially for their disposable forms, is to provide such meters with the open cell according to the present invention.

A portable miniaturized ECG meter is manufactured by CADltec AG, Medical Instruments of CH-1632 Riaz, Switzerland. Such an ECG meter could benefit the advantages of the open cell battery according to the present invention, which advantages are listed herein.

Figure 16 shows a pulse, blood pressure or ECG meter **310**, which includes a housing **312** for housing the required sensors/electrodes therein. Meter **310** further includes an open cell **314** according to the present invention which provides meter **310** with power for its operation. Meter **310** further includes control/operating buttons **315** to turn meter **310** on/off and to control its operation. In addition, meter **310** includes a display **316** for displaying the measurement results. One ordinarily skilled in the art would know how to modify existing meters and sensors to include the open cell according to the present invention.

Another use of the open cell according to the present invention is in active smart cards and smart tags. Smart cards/tags are devices which include electronically encoded information and are in many cases used for electronic authentication of their holder. Due to its properties described herein, the open cell according to the present invention forms a highly advantageous power source for active smart cards/tags. Such a card/tag **350** is shown in Figure 17 to include a thin cell **352** covering its entire surface. Such a card/tag may be manufactured via printing technology, wherein all of its electronic components and power source are printed. The smart card/tag according to the present invention may include a cryptogram or code used for authentication.

Another use of the open cell according to the present invention is in games. Shown in Figure 11 is a game **280** which includes distributed un-raveled components **282** arranged on a substrate **283**. Un-raveled components **282** become revealed if current from an open cell **206**, as hereinabove described, arrives simultaneously or in a predetermined order to components **282**. The arrival of current is activated by a player. To this end components **282** which are to be revealed include a hidden switch, such that when the player presses the component with its finger, the switch closes an electrical circuit.

The game may further include a winning effect(s) which may be any sensible performance, either audial or visual. One of ordinary skills in the art would know how construct components **282** and to generate the winning effect(s).

The production costs of an open cell a described herein are very low since, as further detailed below, the open cell may be mass produced using printing technologies, and further since it requires no casing. The cell may be attached to any device by adhering it to the device or by printing it on the device. Devices which employ the cell are therefore relatively cheap to manufacture and may therefore be disposable. This, in turn, has advantages in many aspects, especially when the device is used for medical purposes such as blood analysis, in mouth temperature determination and transdermal drug delivery or compounds recovery. In the latter, the flexibility of the cell is also a crucial factor since active pads should adhere to the skin at various locations of the body. Since the cell according to the present invention is thin and may cover any surface it is useful in advertising as a part of a medium to deliver information, a game or any other "give away" product which requires power for its operation. To this effect it will be appreciated that the cell may be fabricated from inexpensive, readily available and environmental friendly materials.

The following Example concerns methods for manufacturing the thin layer flexible open cell according to the present invention.

EXAMPLE 9

According to the present invention provided is a method of making a flexible thin layer open liquid state electrochemical cell. The method includes the following steps. First a wet ink is applied onto inner sides of first and second substrates. Suitable substrates include, but are not limited to, paper, polyester or polypropylene foils. The ink is a current conductor. Suitable current conductor inks are distributed under the name "ELECTRODYE" by Acheson Colloiden B. V., the Netherlands, Cat. # 423SS and 109B. Second, before the ink dries, a positive pole powder is applied on the wet ink of the first substrate and a negative pole powder is applied on the wet ink of the second substrate. Since the ink is wet, the powders stick to the ink and since the ink is a current conductor the particles of the respective powders are in electrical contact. Powder application may be devised such that a single layer of powder particles is formed. The cell thus produced will therefore enjoy extra thinness. Third, a porous substance is wetted with an aqueous solution containing a deliquescent material, an electroactive soluble material and a watersoluble polymer. Fourth, the first and second substrates are attached to the porous substance, such that their inner sides face the substance, so that a three layers cell is formed.

In a preferred embodiment of the invention the method further includes the following steps. Fifth, glue is applied onto the inner sides of the substrates or to both sides of the substance. The application of glue is preferably in accordance with a geometrical configuration, such as a star, a circle, a flower shape, etc. Sixth, the three layers cell is cut (e.g., by a laser) according to the geometrical configuration. The glue which is located at the edges of the geometrical configuration ensures that the layers will not separate over time and handling.

In a preferred embodiment of the method, a decorative application is applied onto at least one of the substrates.

Further according to the present invention provided is a method of printing a flexible thin layer open liquid state electrochemical cell. The method includes the following steps. First, a first layer of wet ink is printed onto a substrate. The ink is a current conductive ink. Second, before drying, a layer of a positive pole powder is spread over the first layer of wet ink. Third, a layer of an aqueous solution containing fibers, a deliquescent material, an electroactive soluble material and a watersoluble polymer is printed over the layer of positive pole powder. The fibers may be of any type. Suitable fibers include, for example, cotton non-woven fibers. The fibers and their concentration are selected such that upon drying they will form a porous substance. Fourth, before drying, a layer of negative pole powder is spread over the layer of aqueous solution. Fifth, a second layer of the ink is printed over the layer of negative pole powder. The result is a three layers battery, substantially as depicted in Figure 1.

In a preferred embodiment, the method further includes printing a conductive layer (e.g., carbon or conductive ink) on the substrate prior to the first step above and further printing a conductive layer over the second layer of the ink. The conductive layer includes a conductive carbon powder or a conductive ink, such as a metal ink.

At any stage electrical connections may be printed in contact with the positive and negative pole.

Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

WHAT IS CLAIMED IS:

1. An application comprising an electrically operated device and a flexible thin layer open liquid state electrochemical cell for providing said device with electrical power for its operation, said electrochemical cell including a first layer of insoluble negative pole, a second layer of insoluble positive pole and a third layer of aqueous electrolyte, said third layer being disposed between said first and second layers and including:

(a) a deliquescent material for keeping the open cell wet at all times;

(b) an electroactive soluble material for obtaining required ionic conductivity; and

(c) a watersoluble polymer for obtaining a required viscosity for adhering said first and second layers to said third layer.

2. The application of claim 1, wherein said device includes a substrate material and at least one electronic component attached to said substrate material, said at least one electronic component is for performing a sensible performance.

3. The application of claim 2, wherein said substrate is selected from the group consisting of a greeting card, a business card, a cinema or theater ticket, a sticker for a compact disc, a package of a food product and a printed matter.

4. The application of claim 2, wherein said sensible performance is audial or visual.

5. The application of claim 4, wherein said audial performance is selected from the group consisting of a melody, words of a language and telephone dial tones.

6. The application of claim 2, wherein said device includes a power switch.

7. The application of claim 2, wherein said at least one electronic component is selected from the group consisting of an audio device and a light emitting device.

8. The application of claim 7, wherein said audio device includes an audio chip and an echo chamber.

9. The application of claim 7, wherein said light emitting device is a low-current led.

10. The application of claim 1, wherein said device is a timer.

11. The application of claim 10, wherein said timer includes a substrate material and a timer chip attached to said substrate material, said timer chip is presetable for timing a time period and for prompting a sensible performance when said time period has elapsed.

12. The application of claim 11, wherein said performance is by an audio or light emitting device.

13. The application of claim 11, wherein said sensible performance is audial or visual.

14. The application of claim 13, wherein said audial performance is selected from the group consisting of a melody, words of a language and an alarm.

15. The application of claim 11, wherein said timer chip is programmable.

16. The application of claim 11, wherein said timer chip is resetable.

17. The application of claim 12, wherein said audio device includes an audio chip and an echo chamber.

18. The application of claim 12, wherein said light emitting device is a low-current led.

19. The application of claim 11, wherein said timer is a drug timer.

20. The application of claim 1, wherein said device is an active pad for transdermal delivery of a compound.

21. The application of claim 20, wherein for said transdermal delivery of said compound said active pad employs a strategy selected from the group consisting of iontophoresis, ultrasound and electroporation.

22. The application of claim 20, wherein said compound is selected from the group consisting of a pharmaceutical compound, a cosmetic compound and an anesthetic compound.

23. The application of claim 1, wherein said device is an active pad for transdermal recovery of a compound from a body.

24. The application of claim 1, wherein said device is a thermometer.

25. The application of claim 24, wherein said thermometer includes a thermistor sensor and an electronic chip, said sensor is for sensing a heat magnitude and converting said heat magnitude into electrical parameter of a magnitude corresponding to said heat, said chip is for quantifying said parameter and for translating said parameter into an output of a temperature value.

26. The application of claim 25, wherein said thermometer further includes a display for displaying said temperature value.

27. The application of claim 1, wherein said device is a smart card or tag.

28. The application of claim 1, wherein said device is an interactive book.

29. The application of claim 1, wherein said device is an active pad for transdermal recovery of a compound.

30. The application of claim 29, wherein for said transdermal recovery of said compound said active pad employs a strategy selected from the group consisting of iontophoresis, ultrasound and electroporation.

31. The application of claim 29, wherein said compound is glucose.

32. The application of claim 1, wherein said device is selected from the group consisting of a blood pressure meter, a pulse meter and an ECG meter.

33. The application of claim 1, wherein said device is a glucose sensor.

34. The application of claim 33, wherein said glucose sensor transdermally recovers glucose from a patient.

35. The application of claim 33, wherein said glucose sensor includes a needle for rupturing the skin and obtaining a blood sample, a glucose oxidaze based glucose sensor, a potenciostat and an electronic chip for quantifying a glucose level in said blood sample.

36. The application of claim 1, wherein said device is a game.

37. The application of claim 36, wherein said game includes distributed un-raveled components, said un-raveled components become revealed if current from said cell arrives simultaneously or in a predetermined order to said components, said arrival of current is activated by a player.

38. A method of making a flexible thin layer open liquid state electrochemical cell comprising the steps of:

(a) applying a wet ink onto inner sides of first and second substrates, said ink being current conductor;
(b) before drying, applying a positive pole powder on said wet ink of said first substrate and a negative pole powder on said wet ink of said second substrate;
(c) wetting a porous substance with an aqueous solution containing a deliquescent material, an electroactive soluble material and a watersoluble polymer; and
(d) attaching said first and second substrates to said porous substance, such that said inner sides faces said substance, so that a three layers cell is formed.

39. The method of claim 38, further comprising the step of:
(e) prior to step (d) applying glue onto said inner sides of said substrate or to both sides of said substance, said application of glue is in accordance with a geometrical configuration.

40. The method of claim 39, further comprising the step of:
(f) following step (d) cutting said three layers cell according to said geometrical configuration.

41. The method of claim 40, wherein said cutting is effected by a laser.

42. The method of claim 38, further comprising the step of:
(e) adding a decorative application onto at least one of said substrates.

43. A method of printing a flexible thin layer open liquid state electrochemical cell comprising the steps of:
(a) printing a first layer of wet ink onto a substrate, said ink being current conductive;
(b) before drying, spreading over said first layer a layer of positive pole powder;
(c) printing over said layer of positive pole powder a layer of an aqueous solution containing fibers, a deliquescent material, an electroactive soluble material and a watersoluble polymer;
(d) before drying, spreading over said layer of aqueous solution a layer of negative pole powder;
(e) printing over said layer of negative pole powder a second layer of said ink.

44. The method of claim 43, further comprising the step of:
(f) before step (a), printing a conductive layer on said substrate.

45. The method of claim 43, further comprising the step of:
(f) following step (e), printing a conductive layer over said second layer of said ink.

46. A cylindrical battery comprising a rolled flexible thin layer open liquid state electrochemical cell including a first layer of insoluble negative pole, a second layer of insoluble positive pole and a third layer of aqueous electrolyte, said third layer being disposed between said first and second layers and including:

(a) a deliquescent material for keeping the open cell wet at all times;
(b) an electroactive soluble material for obtaining required ionic conductivity; and
(c) a watersoluble polymer for obtaining a required viscosity for adhering said first and second layers to said third layer.

47. A battery book comprising a plurality of flexible thin layer open liquid state electrochemical cells being detachably assembled into a book assembly, each of said flexible thin layer open liquid state electrochemical cells including a first layer of insoluble negative pole, a second layer of insoluble positive pole and a third layer of aqueous electrolyte, said third layer being disposed between said first and second layers and including:

(a) a deliquescent material for keeping the open cell wet at all times;
(b) an electroactive soluble material for obtaining required ionic conductivity; and
(c) a watersoluble polymer for obtaining a required viscosity for adhering said first and second layers to said third layer.

48. A flexible thin layer open liquid state electrochemical cell comprising a first layer of insoluble negative pole, a second layer of insoluble positive pole and a third layer of aqueous electrolyte, said third layer being disposed between said first and second layers and including:

(a) a deliquescent material for keeping the open cell wet at all times;
(b) an electroactive soluble material for obtaining required ionic conductivity; and
(c) a watersoluble polymer for obtaining a required viscosity for adhering said first and second layers to said third layer;

the cell further comprising a pH sensor in contact with one of said layers.

49. A battery fold comprising a plurality of flexible thin layer open liquid state electrochemical cells being assembled head-to tail into a foldable assembly, each of said flexible thin layer open liquid state electrochemical cells including a first layer of insoluble negative pole, a second layer of insoluble

positive pole and a third layer of aqueous electrolyte, said third layer being disposed between said first and second layers and including:

(a) a deliquescent material for keeping the open cell wet at all times;

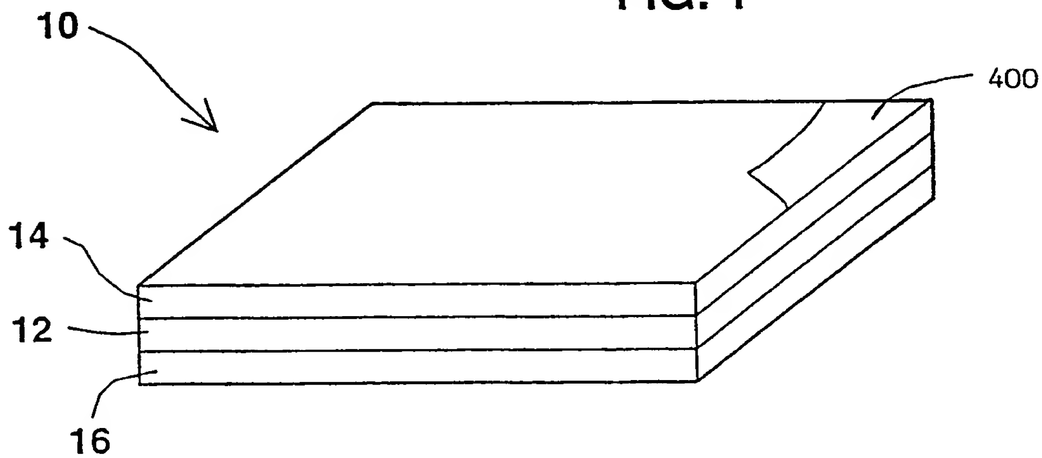
(b) an electroactive soluble material for obtaining required ionic conductivity; and

(c) a watersoluble polymer for obtaining a required viscosity for adhering said first and second layers to said third layer.

50. A compact disc container comprising a container and a sticker attached thereto, said sticker being operable to produce a sensual indication of an audial content of a compact disc expected to be in said container.

51. The compact disc container of claim 50, wherein said sensual indication is audial and includes an audio display identifiable as said audial content.

FIG. 1



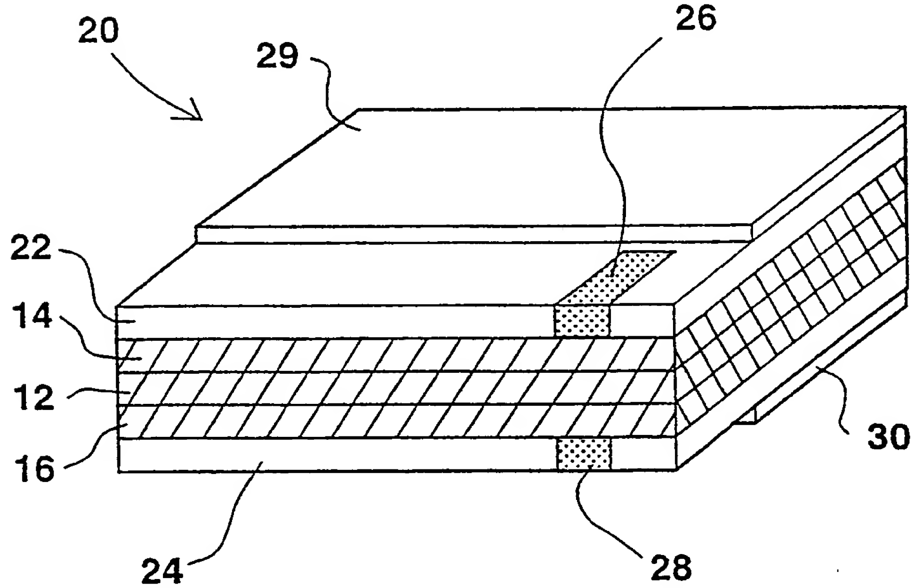
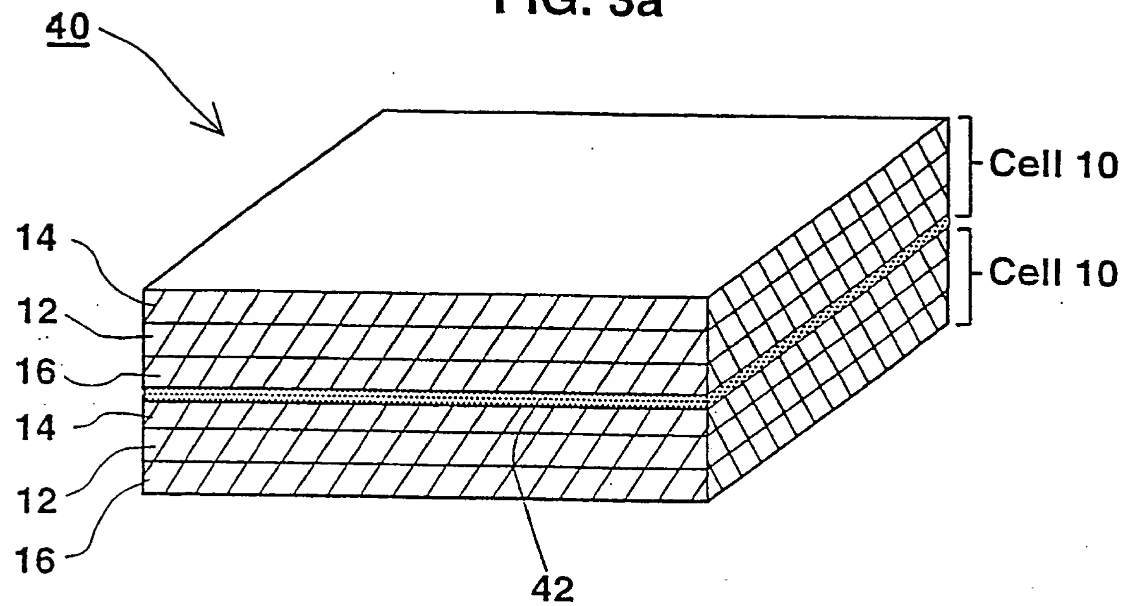


FIG. 2

FIG. 3a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Cell 10
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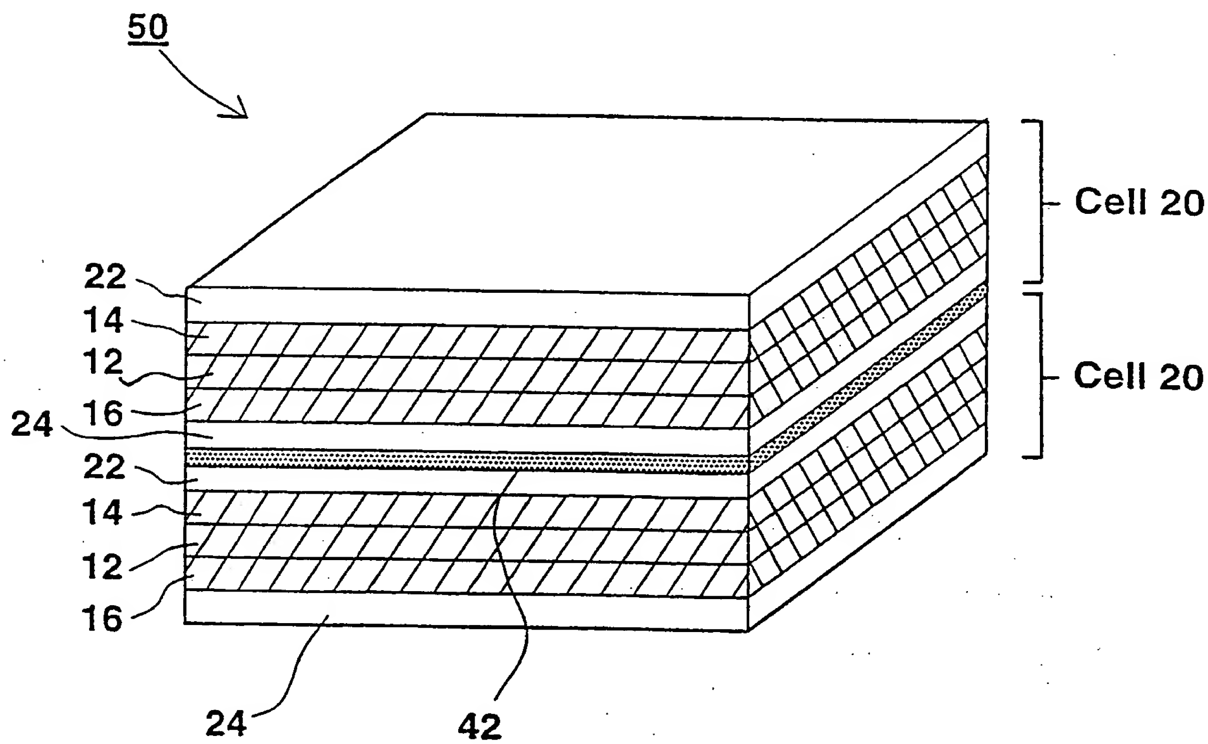
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42

FIG. 3b

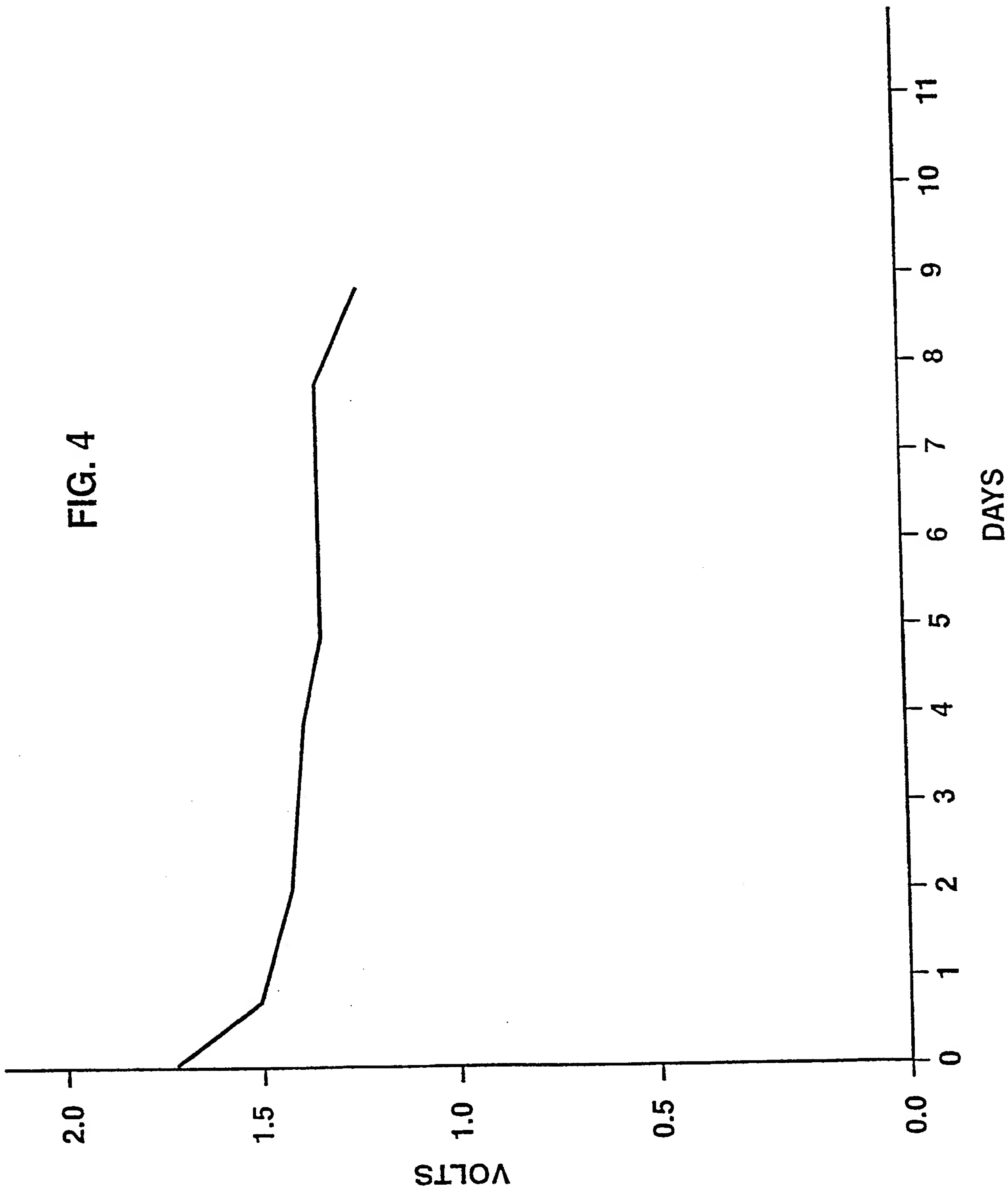

FIG. 4

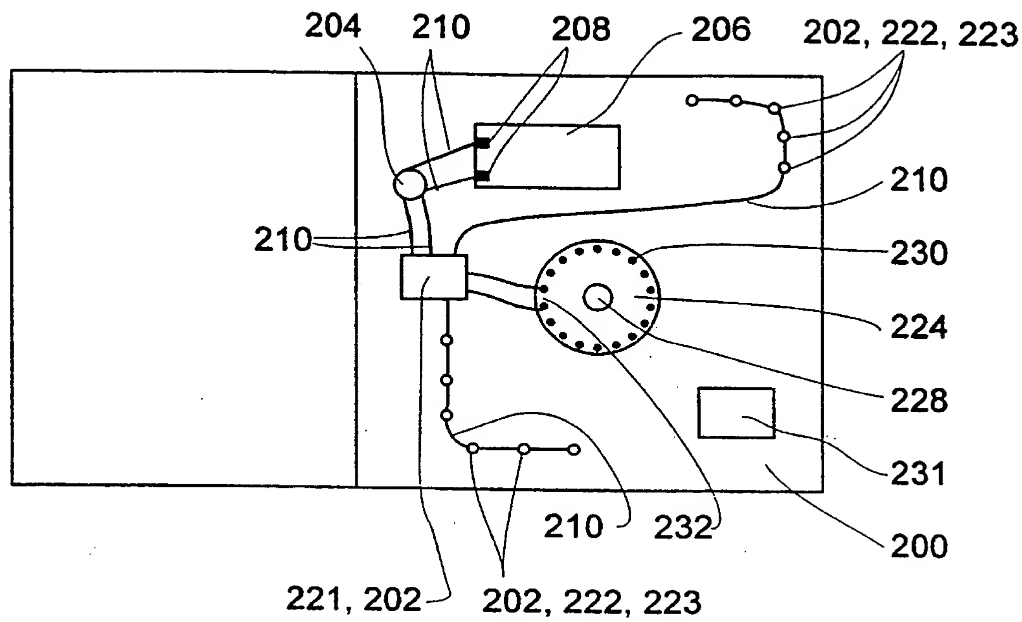

Fig. 5

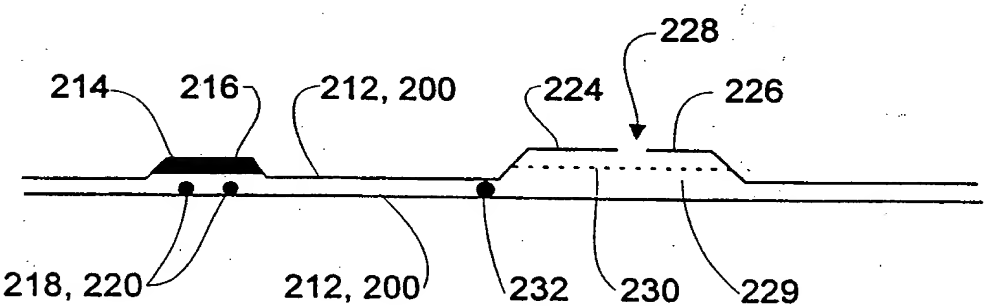

Fig. 6

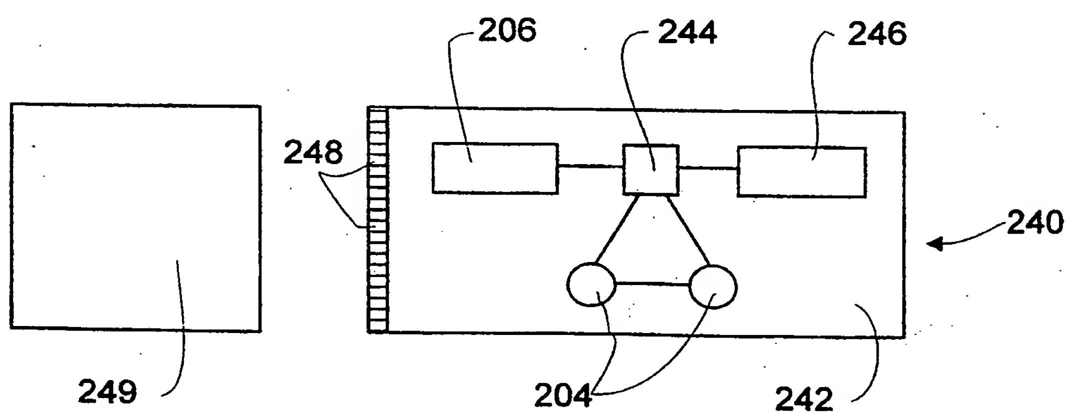

Fig. 7

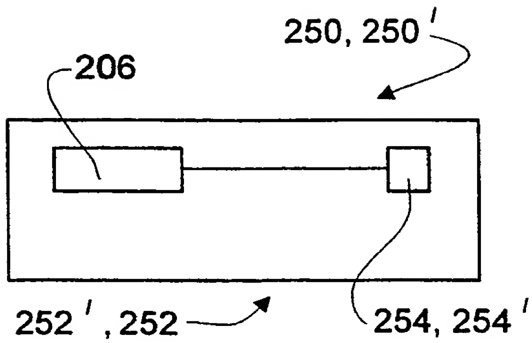

Fig. 8

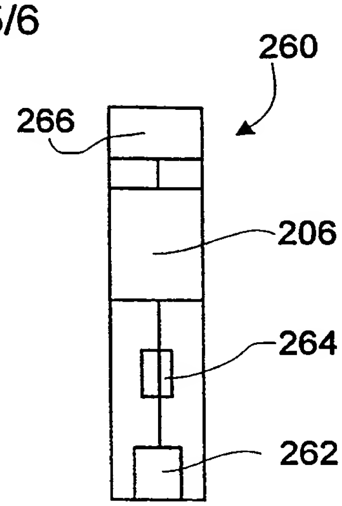

Fig. 9

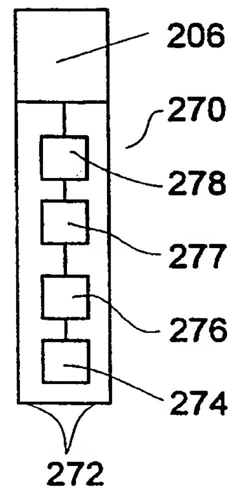

Fig. 10

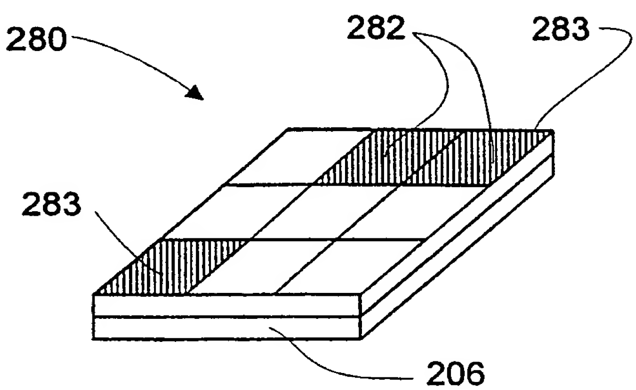

Fig. 11

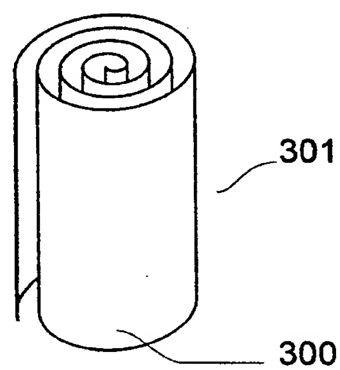

Fig. 12

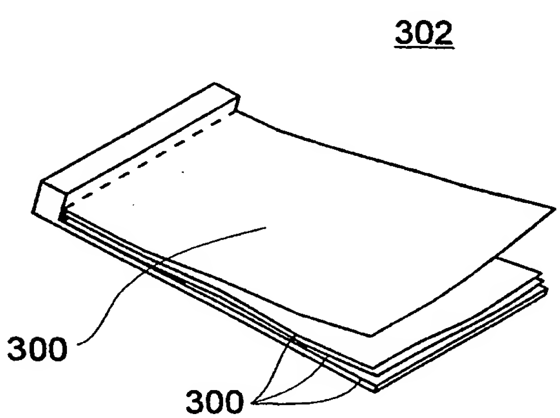

Fig. 13

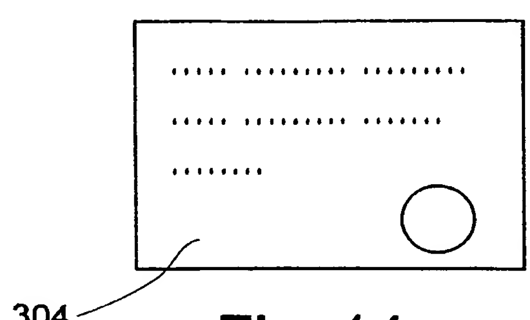

Fig. 14

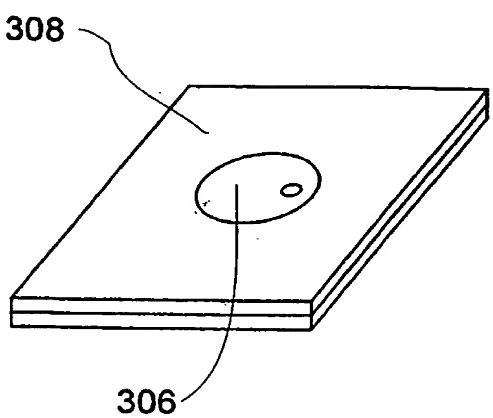

Fig. 15

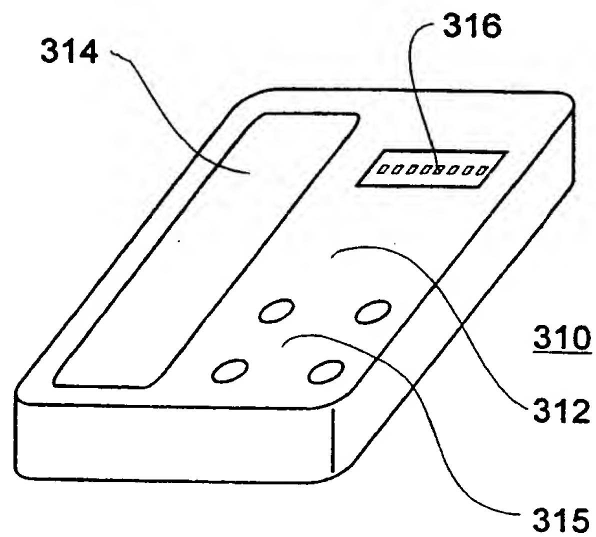

Fig. 16

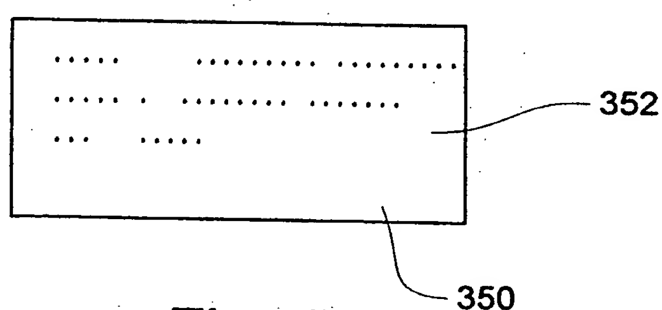

Fig. 17

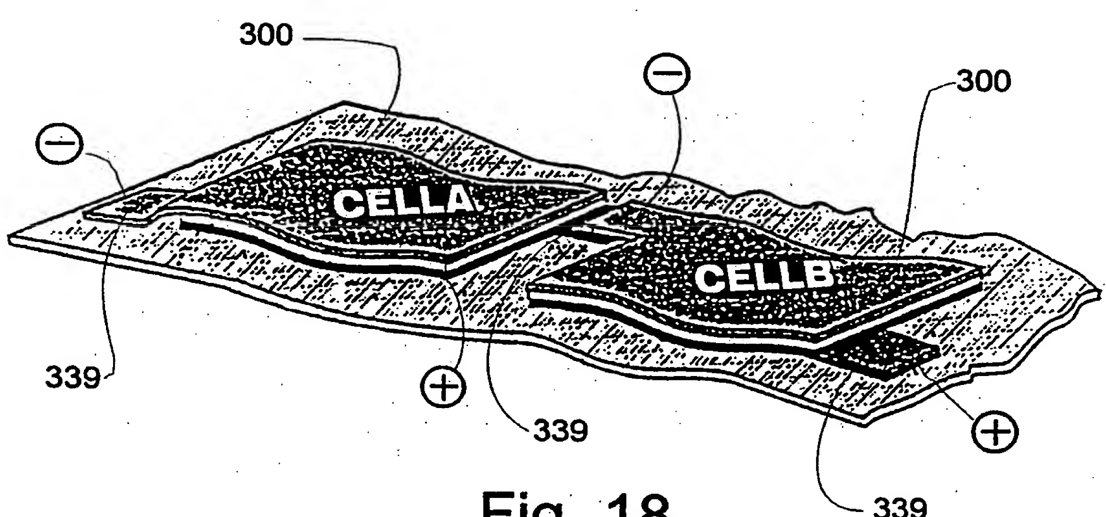

Fig. 18

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/11806

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A61N 1/30; B32B 9/00
US CL :428/209; 604/20
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 428/209; 604/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

128/114.1; 428/210, 688, 701; 429/82, 127, 152, 162, 224, 229; 602/47, 48, 58; 604/21, 890.1; 607/152

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P ----- Y,P	US 5,641,590 A (SATO et al) 24 June 1997, col. 1 line 45 to col. 2 line 5; col. 2 line 50 to col. 3 line 53; col. 4 lines 34-45; col. 7 lines 15-25; and col. 7 line 55 to col. 8 line 50.	1, 2 ----- 3-51
A	US 3,901,732 A (KALNOKI KIS et al) 26 August 1975, col. 1 lines 50-63; and col. 3 lines 28-47.	1-51
A	US 4,119,770 A (LAND) 10 October 1978, col. 1,lines 29-34; col. 2 lines 12-38; col. 4 line 63 to col. 5 line 11; col. 15 line 63 to col. 16 line 15.	1-51
A	US 4,195,121 A (PETERSON) 25 March 1980, col. 2,lines 14-45.	1-51

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 27 JULY 1998	Date of mailing of the international search report 19 AUG 1998
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer Andre Kalinowski SHARON ELIZABETH FINKEL Telephone No. (703) 305-0154